Claims

[c1] 1. A process for removing SO_2, NO, and NO_2 from a gas stream comprising the steps of

a. oxidizing at least a portion of NO in a gas stream to NO_2 with an oxidizing means, followed by

b. scrubbing at least a portion of SO_2, NO, and NO_2 from the gas stream with a scrubbing solution comprising an alkali hydroxide in an amount sufficient to maintain a pH greater than 6, and

c. removing at least a portion of any alkali aerosols generated from the scrubbing step from the gas stream with an aerosol removal means.

[c2] 2. The process of claim 1, said oxidizing means comprising an electrical discharge reactor.

[c3] 3. The process of claim 2, said oxidizing step further comprising adding an alkene to the gas stream upstream of the electrical discharge reactor.

[c4] 4. The process of claim 3, wherein said alkene is at least one taken from the group consisting of ethene and propene.

[c5] 5. The process of claim 2, wherein said electrical discharge reactor is a dielectric barrier discharge reactor.

[c6] 6. The process of claim 5, further comprising the step of oxidizing at least a portion of the NO to HNO_3 with said dielectric barrier discharge reactor.

[c7] 7. The process of claim 1, wherein said oxidizing step is adapted to result in a mole ratio of SO_2 to NO_2 of at least 2 to 1.

[c8] 8. The process of claim 1, wherein said oxidizing step is adapted to result in a mole ratio of SO_2 to NO_2 of at least four to one.

[c9] 9. The process of claim 1, said scrubbing solution comprising alkali, alkali sulfite, alkali sulfate, and water, and having a pH greater than 6.

[c10] 10. The process of claim 1, wherein said alkali is at least one taken from the

group consisting of ammonium, sodium, and potassium.

[c11] 11. The process of claim 1, wherein said aerosol removal means is a wet electrostatic precipitator.

[c12] 12. The process of claim 1, wherein said scrubbing step results in the formation of alkali sulfate, the process further comprising the step of withdrawing alkali sulfate from the scrubbing solution.

[c13] 13. The process of claim 12, wherein said scrubbing step results in the formation of alkali nitrate, the process further comprising the step of withdrawing alkali nitrate from the scrubbing solution.

[c14] 14. A process for removing SO_2, NO, NO_2, and Hg from a gas stream comprising the steps of

a. oxidizing at least a portion of the NO in a gas stream to NO_2, and at least a portion of the Hg in a gas stream to oxidized mercury, with an oxidizing means, followed by

b. scrubbing at least a portion of the SO_2, NO, and NO_2 from the gas stream with a scrubbing solution comprising an alkali hydroxide in an amount sufficient to maintain a scrubbing solution pH greater than 6, and

c. removing at least a portion of any alkali aerosols generated from the scrubbing step, and oxidized mercury not captured in the scrubbing step, from the gas stream with an aerosol removal means.

[c15] 15. The process of claim 14, said oxidizing means comprising an electrical discharge reactor.

[c16] 16. The process of claim 15, said oxidizing step further comprising adding an alkene to the gas stream upstream from the electrical discharge reactor.

[c17] 17. The process of claim 16, wherein said alkene is at least one taken from the group consisting of ethene and propene.

[c18] 18. The process of claim 16, wherein said electrical discharge reactor is a dielectric barrier discharge reactor.

[c19] 19. The process of claim 14, wherein said aerosol removal means is a wet electrostatic precipitator.

[c20] 20. The process of claim 14, said scrubbing solution comprising alkali, alkali sulfite, alkali sulfate, and water, and having a pH greater than 6.

[c21] 21. The process of claim 14, wherein said alkali is at least one taken from the group consisting of ammonium, sodium, and potassium.

[c22] 22. The process of claim 20, wherein said scrubbing step results in the formation of alkali sulfate, the process further comprising the step of withdrawing alkali sulfate from the scrubbing solution.

[c23] 23. A process for removing SO_2, NO, and NO_2 from a gas stream comprising the steps of

a. oxidizing at least a portion of NO in a gas stream to NO_2 with an oxidizing means, followed by

b. scrubbing at least a portion of SO_2, NO, and NO_2 from the gas stream with a scrubbing solution comprising an ammonia in an amount sufficient to maintain a pH greater than 6, and

c. removing at least a portion of any ammonia aerosols generated from the scrubbing step from the gas stream with an aerosol removal means.

[c24] 24. An apparatus for removing SO_2, NO, and NO_2 from a gas stream comprising

a. an oxidizing means for oxidizing at least a portion of the NO in a gas stream to NO_2, followed by

b. a scrubber suitably adapted to scrub at least a portion of the SO_2, NO, and NO_2 from the gas stream with a scrubbing solution comprising an alkali hydroxide in an amount sufficient to maintain the scrubbing solution pH greater than 6, and

c. an aerosol removal means for removing at least a portion of any alkali aerosols generated by the scrubber from the gas stream.

[c25] 25. The apparatus of claim 24, wherein said oxidizing means is at least one

electrical discharge reactor.

[c26] 26. The apparatus of claim 25, wherein said electrical discharge reactor is at least one dielectric barrier discharge reactor.

[c27] 27. The apparatus of claim 26, wherein said dielectric barrier discharge reactor is adapted to oxidize at least a portion of the NO to NO_2 and HNO_3.

[c28] 28. The apparatus of claim 24, said scrubbing solution comprising alkali, alkali sulfite, alkali sulfate, and water, and having a pH greater than 6.

[c29] 29. The apparatus of claim 24, wherein said alkali is at least one taken from the group consisting of ammonium, sodium, and potassium.

[c30] 30. The apparatus of claim 24, wherein said aerosol removal means is at least one wet electrostatic precipitator.

[c31] 31. An apparatus for removing SO_2, NO, NO_2, and Hg from a gas stream comprising

a. an oxidizing means for oxidizing at least a portion of the NO in a gas stream to NO_2, and at least a portion of the Hg in a gas stream to oxidized mercury, followed by

b. a scrubber suitably adapted to scrub at least a portion of the SO_2, NO, and NO_2 from the gas stream with a scrubbing solution comprising an alkali hydroxide in an amount sufficient to maintain the scrubbing solution pH greater than 6, and

c. an aerosol removal means for removing at least a portion of any alkali aerosols generated by the scrubber, and oxidized mercury not captured by the scrubber, from the gas stream.

[c32] 32. An apparatus for removing SO_2, NO, and NO_2 from a gas stream comprising

a. an NO oxidizer adapted to oxidize at least a portion of the NO in a gas stream to NO_2, followed by

b. a scrubber adapted to scrub at least a portion of the SO_2, NO, and NO_2

from the gas stream with a scrubbing solution comprising an alkali hydroxide in an amount sufficient to maintain the scrubbing solution pH greater than 6, and c. an aerosol remover adapted to remove at least a portion of any alkali aerosols generated by the scrubber from the gas stream.

[c33] 33. The apparatus of claim 32, wherein said NO oxidizer is at least one electrical discharge reactor.

[c34] 34. The apparatus of claim 33, wherein said electrical discharge reactor is at least one dielectric barrier discharge reactor.

[c35] 35. The apparatus of claim 34, wherein said dielectric barrier discharge reactor is adapted to oxidize at least a portion of the NO to NO_2 and HNO_3.

[c36] 36. The apparatus of claim 32, said scrubbing solution comprising alkali, alkali sulfite, alkali sulfate, and water, and having a pH greater than 6.

[c37] 37. The apparatus of claim 32, wherein said alkali is at least one taken from the group consisting of ammonium, sodium, and potassium.

[c38] 38. The apparatus of claim 32, wherein said aerosol remover is at least one wet electrostatic precipitator.